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MILKING EQUIPMENT: Function, Design, Installation, Sanitation & Analysis



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MILKING EQUIPMENT: Function, Design, Installation Sanitation & Analysis

Introduction

The milking machine plays an important role on the dairy farm as an efficient means of milking cows. However, it is one of the few devices that has direct contact with living animal tissue. Faulty milking equipment may lead to teat injury and/or mastitis, as well as discomfort to the cow.

Consequently, before attempting to milk cows, you should thoroughly understand the basic operation of the milking equipment, the significance of maintaining equipment in good condition at all times and the importance of good milking techniques.

This publication describes the various components of a typical milking system, their function, approved installation guidelines and recommended sanitation and system analysis procedures.

Milking Machine Function

The milking machine performs two basic functions:

1. It causes milk to flow from a teat by exposing the teat end to a partial vacuum;
2. It massages the teat in an effort to relieve the effects of a continuous milking vacuum.

Vacuum Pump

The milking machine depends upon a partial vacuum for its operation. The vacuum pump creates **partial vacuum** by removing part of the air from the various lines in the milking system.

The amount of air removed will determine the system vacuum level. This level is indicated on the vacuum gauge which will read in either kilopascals (kPa), or millimetres of mercury (mmHg) or inches of mercury (in.Hg). For example, if half of the air is removed from the system, the vacuum gauge would read 50 kPa (381 mmHg or 15 in. Hg) vacuum.

Vacuum pumps are rated on the basis of the volume of air they can expel when the intake vacuum is at 50.7 kPa (381 mmHg or 15.0 in.Hg). **Litres per minute (L/min.)** and **Cubic Feet per Minute (CFM)** are the standard air flow measurements used. A pump's CFM rating is usually expressed according to the American Society of Mechanical Engineers' (ASME) Standard for air flow measurements. Some pumps may be expressed in terms of the New Zealand (NZ) Standard which is double the ASME Standard. One (1.0) CFM ASME = 2.0 CFM NZ = 28.3 L/min. ASME.

Install the vacuum pump in a clean, dry, well-ventilated area. Intake and exhaust pipes **must be steel or copper**. Both pipes must be **at least as large as** the intake and exhaust connections of the pump, otherwise, pump output and life will be decreased and it will run hotter and require increased maintenance. Provisions must be made to measure vacuum pump capacity at the pump (see section

entitled Plumbing Provisions for System Air Flow Analysis).

Install a rubber sleeve with two hose clamps between the steel or copper intake pipe of the pump and main vacuum supply line that feeds into the vacuum reserve tank. This installation serves two purposes:

1. It allows for quick and efficient removal of the vacuum pump for either servicing or replacement;
2. It helps dampen the vibration generated by the vacuum pump and reduces the transmission of this vibration throughout the milking system.

Warning: Do not use a radiator hose with a steel spring instead of a rubber sleeve, since the spring will rust and fragments could enter the vacuum pump leading to serious internal damage.

The installation of a flapper (check) valve on the exhaust pipe prevents pump backspin and potential damage to interior vanes when the pump is shut off. Other preparations include installing an hour meter on the pump to monitor usage; checking oil daily and knowing how to adjust the dispensing rate; and ensuring that oil is clean and getting into the pump. Vacuum pump belts should be checked regularly for wear, tension and alignment. Loose belts can have a significant negative effect on pump capacity and airflow through the entire milking system.

Where an oil reclaimer is on the pump, closely adhere to maintenance recommendations highlighted in the owner's manual. If the oil and filter in the oil reclaimer are not changed frequently enough, the filter can plug and restrict oil flow. This will cause the pump and oil to over-heat leading to excessive wear and premature pump damage or failure.

For bucket milkers, it is recommended a minimum air reserve of 17 CFM ASME plus 2 CFM ASME per unit be provided. An additional 5 CFM ASME is required for vacuum operated milk transfer systems.

Table 1 is a guideline for matching a system's air flow requirements to vacuum pump capacity.

Table 1. Pipeline Systems for Standard Parlors and Stall Barns

# of Units	Minimum Vacuum Pump Capacity	
	L/min.	CFM (ASME)
3 or fewer	849	31
4	1020	36
6	1475	52
8	1870	66
10	2265	80
12	2550	90
16	3170	112
20	3565	126

NOTE: A 5 HP pump (minimum) for small stanchion systems (i.e. less than 6 units) is recommended.

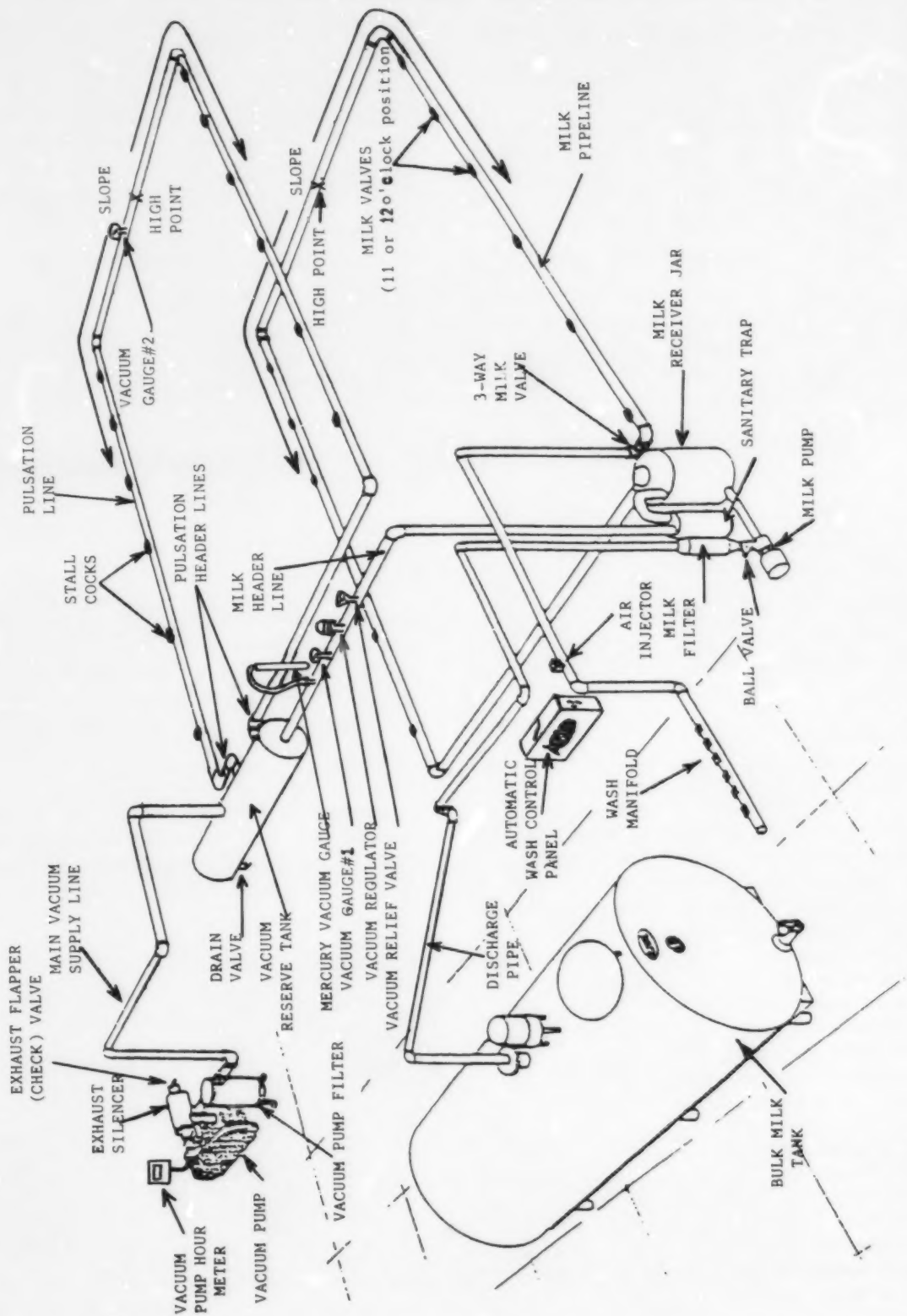


Figure 1. Typical Milking System

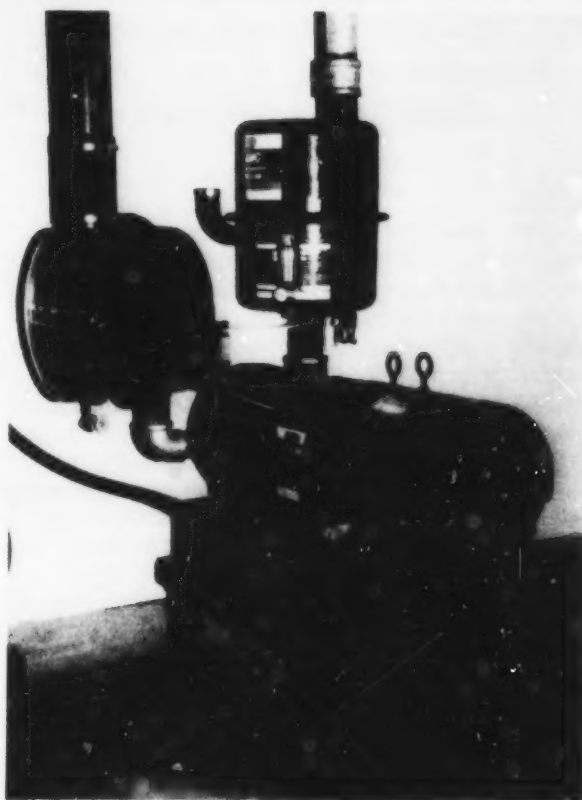


Photo 1. Vacuum Pump with Oil Reclaimer

Vacuum Reserve Tank

The Vacuum reserve tank is commonly referred to as a balance, buffer or distribution tank. The main function of a vacuum reserve tank is as an intermediary between the pump and the system's plumbing by connecting all of the plumbing at a common site. It also provides a **reserve of vacuum** to help offset or buffer sudden air admissions into the system (i.e. unit fall-off). Reserve is a function of pump capacity and performance, regulator operation and the degree of system leakage.

The tank must be self-draining and should be constructed of durable material to withstand highly concentrated solutions of chemical cleaners and sanitizers. Tanks may be constructed of galvanized steel, stainless steel or plastic (PVC) with the latter two being recommended. PVC tanks, however, are preferable due to their low cost, ease of maintenance, rust resistance, long life and lightweight nature.

Vacuum tank capacity must not be less than 20 L (4.4 gal.) per unit with a mini-

mum size of 75 L (16.5 gal.) but need not exceed 170 L (40 gal.) for any installation.

The tank must be located on the main vacuum supply line. The tank must also have at least four ports with each being 76 mm (3.0 in.) or greater in diameter.

Check the drain valve periodically for wear, plugs and air leaks. Drain valves are either of the rubber flapper valve or small ball valve variety.

Vacuum Regulator (Controller)

The function of the vacuum regulator is to keep the vacuum of the milking system at a **preset level** by responding to changing air admissions into the system. The regulator must have sufficient capacity to admit air at a rate equal to 125% of the full vacuum pump capacity at an operating vacuum of 50.7 kPa (381 mmHg or 15.0 in.Hg). Only one vacuum regulator should be mounted on a milking system.

The regulator must also be sensitive enough that, under normal operating conditions and adequate vacuum pump capacity, it will not permit the vacuum in the milking vacuum supply line (sometimes referred to as the milk header line) to fluctuate more than ± 1.7 kPa (12.7 mmHg or 0.5 in.Hg).

The vacuum regulator is located in either a separate inlet to the vacuum reserve tank or in the milking vacuum supply line between the vacuum reserve tank and the sanitary trap. Location will vary among manufacturers so refer to the owner's manual for regulator installation specifications. Also, the regulator should be mounted in an area where the air is relatively clean and dry, where air temperature always exceeds 0°C (32°F), and where it is easily accessible for cleaning and vacuum adjustments.

Servo-diaphragm regulators are highly recommended since they are the most sensitive style available. Older, less sensitive styles such as the weighted (steel and oil bath) and spring-controlled regulators still exist.

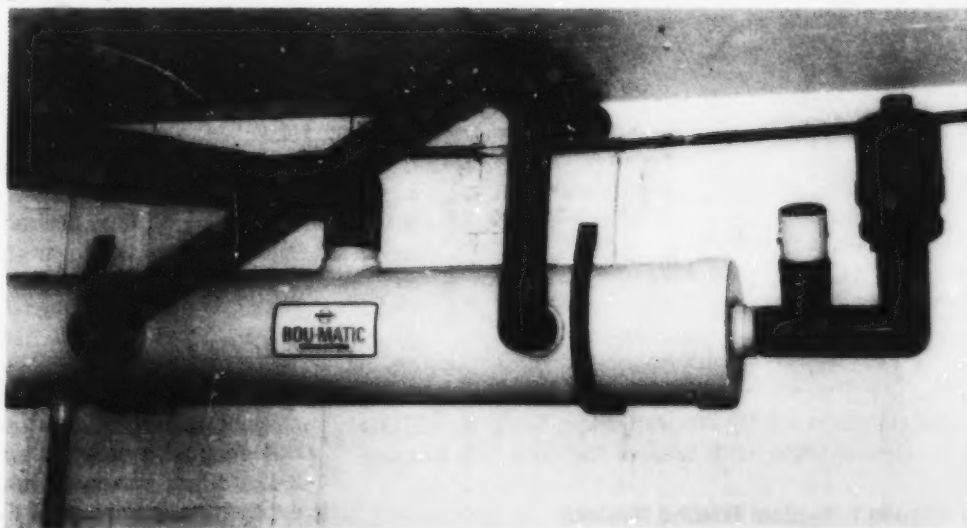


Photo 2. Ceiling-mounted PVC Vacuum Tank

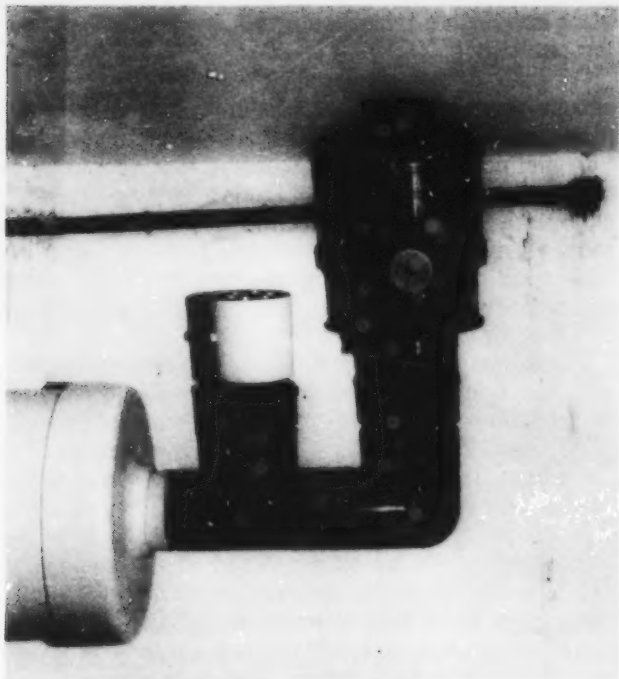


Photo 3. Vacuum Relief Valve alongside a Servo-diaphragm Regulator

Get an owner's manual for the regulator and closely adhere to the prescribed maintenance schedule to ensure that the regulator's sensitivity is constantly maintained.

Increased pump capacity cannot compensate for poor regulator function. Likewise, a sensitive regulator cannot compensate for a deficiency in pump capacity.

Vacuum Relief Valve

For **safety reasons**, a vacuum relief valve should be installed to limit the system vacuum from increasing by more than 5.1 kPa (38 mmHg or 1.5 in.Hg) above normal operating vacuum in case of a malfunction in the regulator.

Install the vacuum relief valve near the regulator, preferably on the milking vacuum supply line, between the vacuum reserve tank and the sanitary trap.

Dial Vacuum Gauge

The vacuum gauge **measures** the system vacuum. The gauge should not be less than 76 mm (3.0 in.) in diameter with dial readings between 0 and 102 kPa (0.0 and 765 mmHg or 0.0 and 30 in.Hg). A calibrating screw is required.

The gauge must be accurate to within ± 1.7 kPa (12.7 mmHg or 0.5 in.Hg). At the time of installation, the vacuum gauge should be calibrated with a portable mercury vacuum gauge (manometer) with increments of 0.3 kPa (2.5 mmHg) (0.1 in.Hg).

Two vacuum gauges are recommended for the milking system. One should be installed on the milking vacuum supply line near the regulator and a second one in a visible position at the far end of the vacuum pulsation line.

Mercury Vacuum Gauge (Manometer)

A mercury vacuum gauge that taps into the milking vacuum supply line near the regulator and system vacuum gauge is also recommended. Open well and U-tube types of mercury gauges are available. Each must be sealed when not in use to protect the mercury from dust and moisture contamination which can make them unreadable and inaccurate. Select a mercury gauge with a graduated scale in increments of 0.3 kPa (2.5 mmHg or 0.1 in.Hg).

Mercury vacuum gauges should never be permanently connected to the milking system. The intent of a mercury gauge is to **check the accuracy** of both system vacuum gauges on a regular basis and for making accurate system **vacuum adjustments** with the vacuum regulator.

The mercury gauge should be installed in a dry location out of reach of children and protected from potential damage and mercury spills.

Vacuum Line Plumbing

Line size selection and plumbing of the main vacuum supply line connecting the vacuum pump to the vacuum reserve tank, then subsequently to both the pulsation and milk lines, is a critical determinant of system air flow characteristics to the milk claw.

Plastic (PVC) vacuum supply lines are preferred over

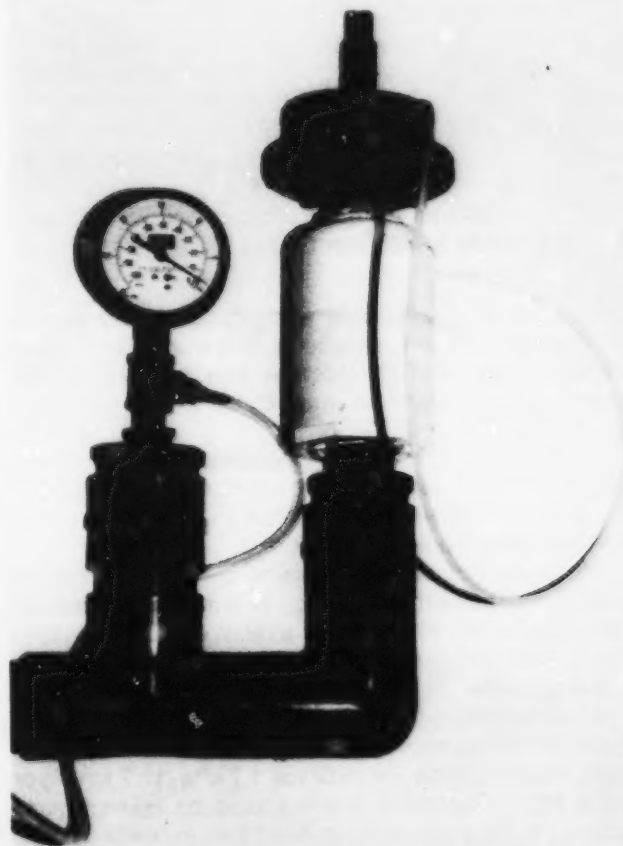


Photo 4. Dial Vacuum Gauge

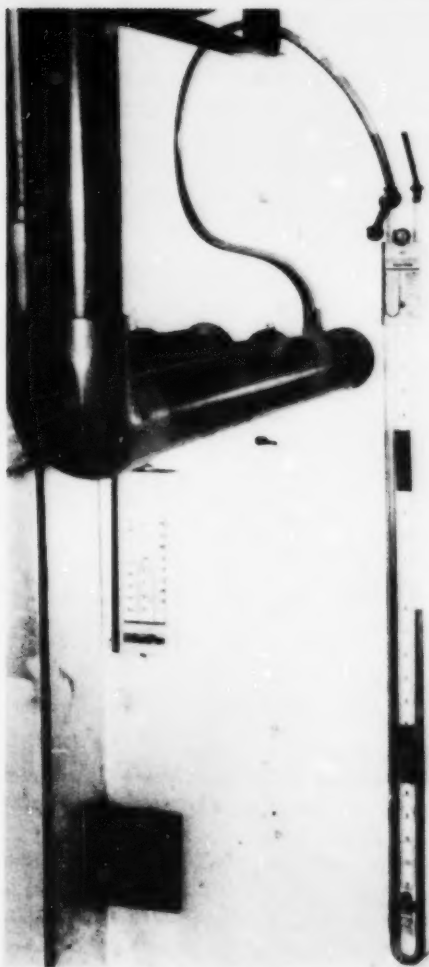


Photo 5. Mercury Vacuum Gauge

galvanized steel since they won't corrode, they provide less friction to air flow and elbows have a larger centre-line radius for bend. PVC must comply with PVC 1120 Schedule 80 or its equivalent and must be identifiable as such at time of installation.

Air leakage at PVC line connections is a common problem unless proper gluing procedures are followed at the time of installation. This includes the use of a primer followed by an application of solvent.

Keep the number of elbows to a minimum. Excess elbows decrease the efficiency of a milking system by reducing the rate of air flow as a result of frictional losses due to changing the direction of air movement. Surplus elbows are also an unnecessary installation expense.

Line restrictions can impede air flow in the vacuum line. Restriction is excessive if the "vacuum head loss" in the main vacuum supply line exceeds 1.7 kPa (12.7 mmHg or 0.5 in.Hg). Corrective action should be taken if such occurs. In the event vacuum head loss exceeds 3.5 kPa (25.4 mmHg or 1.0 in.Hg), increase the size of the main vacuum supply line. Vacuum head loss can be calculated

using appropriate tables found in Appendix I at the end of this publication.

The size of the main vacuum supply line between the vacuum reserve tank and the vacuum pump must be equal to or greater than the size of the intake port of the pump. The inlet port of the vacuum reserve tank should be as large as the main vacuum supply line from the pump. PVC pipe can be used to connect the vacuum reserve tank to the short piece of steel or copper pipe projecting from the intake port of the pump. Connect the two pipes with a rubber sleeve and use hose clamps to create a tight fit and eliminate air leakage.

There should be four inlets on the vacuum reserve tank with one connecting to the main vacuum supply line from the vacuum pump and the other three connecting to outgoing lines that service the pulsation and milking sides of the system. These three are called **header lines** and each should be equal to or larger than the line sizes used in the milking system. One header line should lead to the sanitary trap, while the other two should exit the vacuum tank to form a completely looped pulsation line.

To assist in the inspection and analysis of header and pulsation lines, tees, complete with removable plugs, should be installed in several locations instead of elbows.

Where only one 51 mm (2.0 in.) header line is tee'd into a 51 mm (2.0 in.) looped pulsation line, air flow efficiency will be sacrificed by about 20%. Improvements in air flow can be achieved if two 51 mm (2.0 in.) header lines exit the vacuum tank to form a completely looped line. For older vacuum tanks which don't have an extra outlet to accommodate a second header line to the pulsation line, install a 76 mm (3.0 in.) header line and tee it into the 51 mm (2.0 in.) looped line. Again, the preferred installation is a completely looped line from the vacuum tank.

Pulsation lines should be sloped at least 12.5 mm per 3 metres (0.5 in./10 ft.) in the direction of air flow or 25 mm per 3 m (1.0 in./10 ft.) if parallel to the milk line. Vacuum lines must be adequately supported to eliminate sagging problems. Automatic drain valves must be installed at each low point or riser.

Most pulsators require about 28.3 L/min. (1.0 CFM ASME) per pulsator, however, some use more. Size according to Table 2.

Table 2. Pulsation Line Size

# Pulsators	Line Size
1 - 14	50.8 mm (2.0 in.)
15 or more	76.2 mm (3.0 in.)

NOTE: With only a moderate cost increase, consider installing 76 mm (3.0 in.) PVC pipe as it is stronger than 51 mm (2.0 in.) PVC pipe. However, because installation of 76 mm (3.0 in.) PVC line adds considerable internal volume to the system, ensure that pump capacity is adequate.

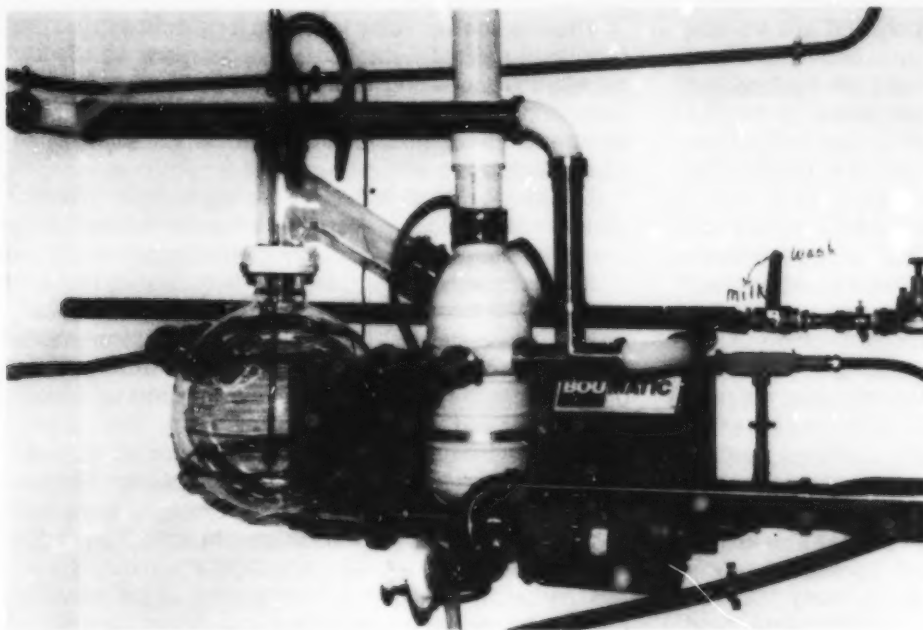


Photo 6. Upgraded Sanitary Trap and Receiver Jar Assembly

Plumbing Provisions for System Air Flow Analysis

To assist the individual conducting a **complete system air flow analysis**, it is recommended that two 76 mm (3.0 in.) tees and four gate valves be installed as follows:

1. One tee and gate valve between the vacuum pump and vacuum reserve tank;
2. One tee and gate valve between the vacuum reserve tank and sanitary trap;
3. Two gate valves on the pulsation line loop (i.e. one gate valve per header line). If only one header line exists then only one gate valve is required.

As a precautionary measure against the accidental closing of a gate valve, split a plastic hose and place it over the shaft of the gate valve when it's in an open position. Remove when taking readings. Installing each gate valve so the shaft hangs downward when it's in the open position, also ensures against partial closure due to vibration.

Milk Receiver Jar/Sanitary (Moisture) Trap

All air flow used to milk the cow is supplied through the sanitary (moisture) trap. For parlor systems with weigh jars, milking vacuum is supplied to the tops of the weigh jars usually by a stainless steel line that is also a wash supply line. In these systems, there's usually a sanitary trap above the sink complete with a milk/wash valve. During milking, this valve is opened to allow the vacuum pump to supply vacuum to the top of the weigh jars.

Avoiding restrictions through proper sizing of the trap and receiver jar is critical to milking system performance. Undersizing can restrict and reduce air flow, increase unit-on time, limit herd milk production and decrease herd average butterfat test.

The function of the sanitary trap is to **protect** the vacuum supply side of the milking system from potential damage caused by chemical cleaning and sanitizing solutions. It also separates the "air only" portion of the system from the milk handling side of the system.

The sanitary trap can be either PVC or stainless steel; the receiver jar either glass or stainless steel.

Equipment manufacturers have acknowledged the importance of proper sizing on new installations by going to 76 mm (3.0 in.) traps connected to receiver jars with a 76 mm (3.0 in.) vacuum supply inlet. The glass or stainless steel connecting sanitary pipe must slope toward the trap at 12.5 mm per 0.66 m (0.5 in./2 ft.). The

trap must be self-draining and installed so any liquid collected in the trap cannot get back into the receiver jar.

For new installations or upgrades to existing systems, install a double inlet receiver jar with **minimum 51 mm (2.0 in.)** milk inlets to accommodate a double sloped milk line with minimum size of 51 mm (2.0 in.). Receiver jar inlets **must be at least the same diameter** as the milk line to which they are connected. To eliminate another potential source of air flow restriction, the vacuum supply inlet of the receiver jar **should be 76 mm (3.0 in.)** in diameter.

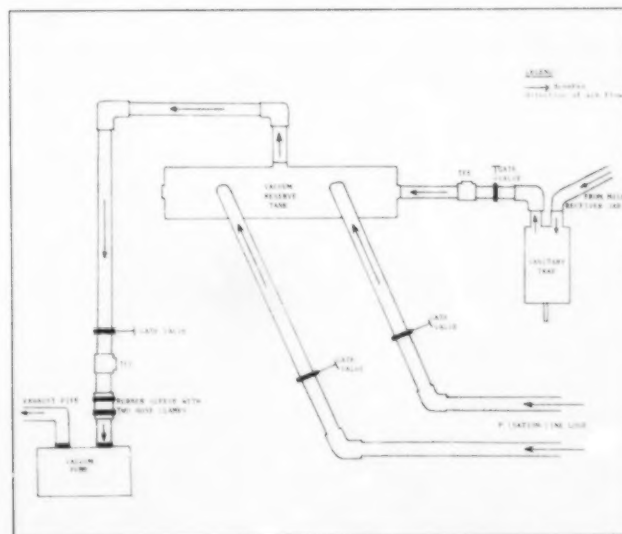


Figure 2. Location of Tees and Gate Valves for System Air Flow Analysis.

Most new systems are being installed with three 76 mm (3.0 in.) inlets, one for vacuum supply and two for milk entry, which eliminates restrictions and allows for future expansion to a larger milk line if the present line is less than 76 mm (3.0 in.). In instances where the jar has 76 mm (3.0 in.) milk inlets but the milk line is only 51 mm (2.0 in.), or 65 mm (2.5 in.), a tapered fitting must be installed between the milk line and the receiver inlet.

Some high producing herds can flood a 51 mm (2.0 in.) double sloped milk line that has adequate slope, with as few as three units per slope if cows are heavy, fast let-down producers. To correct this situation, upgrade the milk line size to 65 mm (2.5 in.) or 76 mm (3.0 in.) rather than cutting back to two units per slope. Trap and receiver inlets **must be at least the same diameter** as the upgraded milk line or else a serious restriction to air and milk flow will still exist.

Testimonials from producers and from milking equipment consultants who've advised producers to upgrade from an undersized and restrictive trap and receiver jar to at least a dual milk inlet 51 mm (2.0 in.), preferably 76 mm (3.0 in.), receiver jar with a 76 mm (3.0 in.) vacuum supply inlet feeding into a 76 mm (3.0 in.) sanitary trap are reporting significant improvements in milking time, herd production and udder health.

A large part of this success is due to improvements in system air flow characteristics. Depending on the severity of air flow restrictions at the trap and/or receiver jar, the payback period from making an upgrade to either component or both, may be as short as one year.

Milk Pipeline

The milk line serves two important functions: to transport milk from the cow to the receiver jar and to carry air flow to milk the cows.

Glass or stainless steel are considered equally good. Remember to protect milk lines, especially glass lines,

where they cross alleyways.

The milk line should be looped to form a circuit, must be supported rigidly by standards that are permanently secured to the floor along the front of the stalls, must have no risers and must have self-draining, self-closing milk inlets which enter the upper one-third of the line, preferably in the 11 or 12 o'clock position.

Milk lines and weigh jars in parlors should be installed **as low as practical**, preferably below udder level. Milk lines in stall barns should be installed no higher than 2.1 m (7 ft.), preferably 1.8 m (6 ft.) or less, above the cow platform. Milk hoses should not exceed 2.7 m (9 ft.).

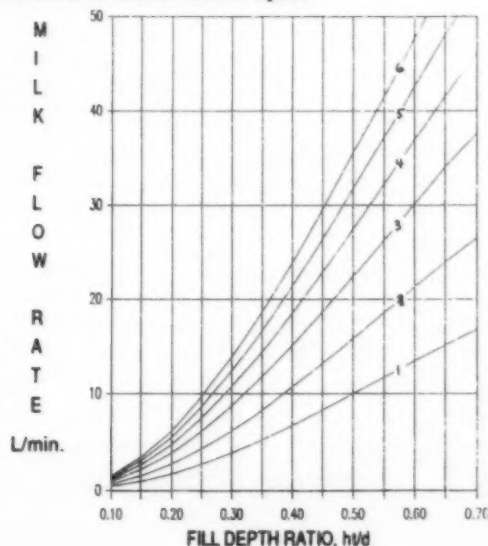
For new tie-stall installations, it is highly recommended that the foundation, floor and gutter be sloped from one end of the barn to the other and that the milk house be located at the lower end. Particularly in long barns, this will help to minimize line height and to ensure that line slope meets minimum recommended standards facilitating milk line drainage during milking and washing. With the line's high point at the high end, this will ensure that both slopes in the milk line are being utilized during milking.

Line height can be further minimized by installing the milk line below the pulsation line.

The milk line must be self-draining and should have a **continuous slope** from the high point toward the milk receiver jar of at least **25 mm per 3 m (1.0 in./10 ft.) for welded lines and 38 mm per 3 m (1.5 in./10 ft.) for coupled lines**. The use of a surveyor's level at the time of installation is recommended. Correct slope is just as important to the proper cleaning of lines as it is to the movement of milk and air during milking.

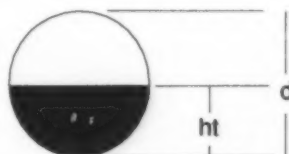
Figure 3 shows the relationship between milk flow rate (L/min.) and milk line fill depth ratio (height/diameter) for different milk line slopes. Line diameter for this example is 51 mm (2.0 in.). Slopes examined are reported in mm (in.) / 3.05 m (10 ft.): no slope; 7.6 mm (0.3 in.); 15.2 mm (0.6 in.); 22.8 mm (0.9 in.); 30.4 mm (1.2 in.); 38.0 mm (1.5 in.).

Figure 3. Milk Flow Rate versus Milk Line Fill Depth Ratio for Different Milk Line Slopes



LEGEND

mm (In.) Slope #	Slope Per 3.05 m (10 ft)
1	No Slope
2	7.6 mm (0.3 in.)
3	15.2 mm (0.6 in.)
4	22.8 mm (0.9 in.)
5	30.4 mm (1.2 in.)
6	38.0 mm (1.5 in.)



SOURCE: Gates, R.S., R. Sagi and R.W. Guest. 1982. Criteria for Optimizing Size and Configuration of Milk Pipelines. J. Dairy Sci. 65: 410-418.

in.); 22.8 mm (0.9 in.); 30.4 mm (1.2 in.); 38.0 mm (1.5 in.) /3.05 m (10 ft.).

Note how an increase in line slope has a significant impact on the milk flow rate at all fill depths, particularly under heavy milk load conditions.

The number of units a milk line can handle should be based on line diameter, line slope and level of herd production. Too many units per slope will lead to milk line flooding and a reduction in air flow rate. This in turn will increase milking time, limit herd milk production and lead to a higher incidence of undesirable teat end vacuum fluctuations.

An obvious sign of **milk line flooding** is when **slugs of milk** are formed. In stainless steel lines, this can only be observed at the receiver jar. Ideally, milk should always enter the jar in a slow continuous flow and not in spurts or slugs.

Assuming there is adequate vacuum pump capacity, proper plumbing of the system from the vacuum pump to the trap, no restrictions at the trap and receiver jar and adequate milk line slope, a milk line which is **half full of milk** can have a negative impact on milking time, herd production and udder health. When half full, enough of the line's inner carrying capacity has been displaced with milk that air flow rate and volume is dramatically reduced in the line and down through to the milk claw.

The recommended minimum milk line size is 51 mm (2.0 in.). It should be noted that a 51 mm (2.0 in.) glass line is an inside diameter while with stainless steel it is an outside diameter. Upgrading from a 38 mm (1.5 in.) to a 51 mm (2.0 in.) stainless steel line will increase the cross-sectional area of the line by 86.5% (Table 3).

It should be emphasized that the actual increase in milk and air carrying capacity from one size of line to the next larger size is even greater than the increase in the cross-sectional area. This is assuming that each line size has the same degree of slope, length, and number and type of elbows.

Table 3. Cross-sectional Areas of Different Size Lines*

Stainless Steel Line mm (in.)	Inside Cross-sectional Area mm ² (in. ²)	% Increase in Cross-sectional Area vs. a 38.1 mm (1.5 in.) Stainless Steel Line
38.1mm(1.5 in.)	955mm ² (1.48 in. ²)	—
50.8mm(2.0 in.)	1781mm ² (2.76 in. ²)	86.5
63.5mm(2.5 in.)	2865mm ² (4.44 in. ²)	200.0
76.2mm(3.0 in.)	4187mm ² (6.49 in. ²)	338.5

* ASSUMPTION: Stainless steel lines made of 18 gauge material with an approximate wall thickness of 1.59 mm (1/16 in.).

Herd production level is a big determinant of the number of units that can be safely handled per slope. For example, the recommended maximum number of units per slope with a 51 mm (2.0 in.) milk line could vary from three to four units depending on herd production.

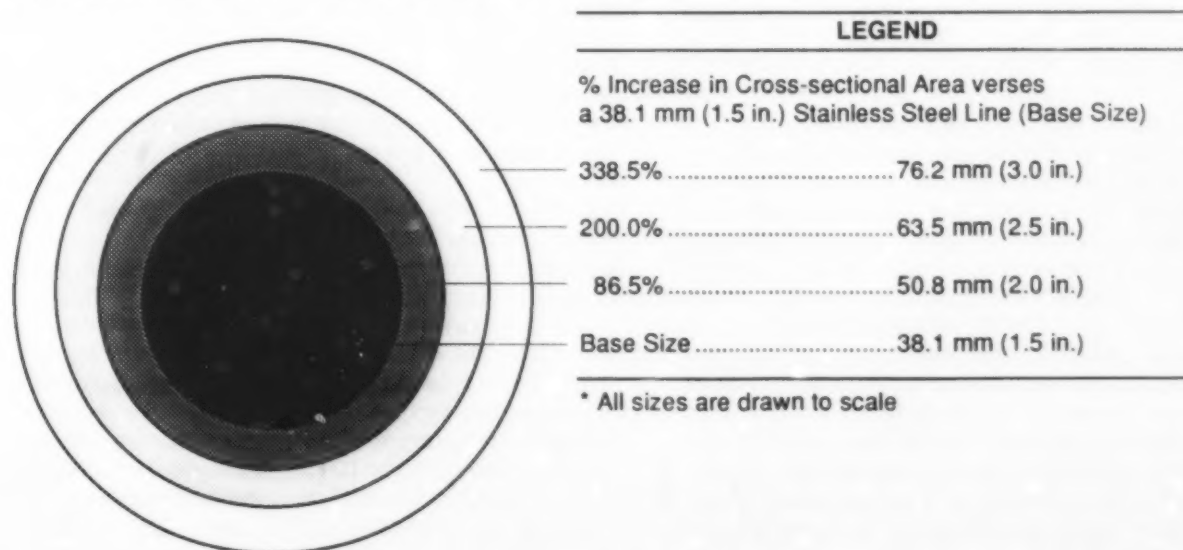
Table 4. Maximum Number of Units per Slope*

Line Size mm (in.)	Maximum # Units Per Slope	Maximum # Units on a Double Sloped System
50.8 mm (2.0 in.)	4 **	8
63.5 mm (2.5 in.)	6	12
76.2 mm (3.0 in.)	9	18

* ASSUMPTION: Each line size is sloped according to recommended standards, is of similar length, and has the same number and type of elbows.

** For high-producing herds, three units per slope is the maximum# recommended for a 51 mm (2.0 in.) milk line.

Figure 4. Cross-sectional Areas of Different Size Lines*



For milking parlors without weigh jars, larger 65 mm (2.5 in.) or 76 mm (3.0 in.) diameter pipelines should be installed and, if possible, should be low lines located below the cow's udder. Parlours with weigh jars can get by with a smaller milk line (minimum 51 mm (2.0 in.)) since the milk line is used **only** for milk transport during emptying of the jars following milking. Going to larger milk lines in parlors with weigh jars may create a real challenge to clean.

Milk Pipeline Couplers

Couplers must be sanitary, leak proof and able to hold the pipeline rigidly together with minimum maintenance. Plastic or nylon used as couplers must be provided with additional pipeline hanger supports located close to the inlet connections and at each corner elbow. Stainless steel welded lines are quite acceptable as long as proper welding techniques are followed and a smooth weld on the inside surface is obtained. Stainless steel welded pipelines should have some removable sections to facilitate internal pipe inspections.

Milk Pipeline Inlets (Valves)

Milk inlets or valves must be located in the **top third** of the milk line, preferably in the 11 or 12 o'clock position. Ensure inlets are located so that milk is not pushed into milk flow or else irregular teat end vacuum fluctuations will occur. Inlets must be self-draining and self-closing. An inlet should be of a design that minimizes air admission when connecting or disconnecting a milk cane or hose.

Milk inlets are available in **14 mm (9/16 in.)** and **16 mm (5/8 in.)** sizes and in three basic designs (slider, nipple and flip open). The slider milk inlet is preferred. Its basic design restricts air admission when attaching and detaching the milk cane. The cane on the end of the long milk hose attaches to the edge of the slider inlet cover and can be slid in one quick motion (with the cover) over the milk inlet port.

Rubber gaskets, if they exist in the milk inlet, should be replaced every one to two years. Repair loose inlets immediately, since loss of air flow capacity due to leakage can become significant.

Milk Canes

The milk cane connects the milk hose leading from the claw to the milk inlet on the pipeline. A milk cane is preferable to just a milk hose that attaches directly to certain older styles of milk inlets. In the latter situation, the milk hose may flatten out with time and create a serious restriction to air and milk flow.

Milk canes can be either plastic or stainless steel. Stainless steel is preferred to plastic, particularly in systems where the canes are repeatedly connected and disconnected, since plastic can soon become worn and scratched.

As with milk inlets, canes are available in either **14 mm (9/16 in.)** or **16 mm (5/8 in.)** sizes (inside diameter). Smaller 14 mm (9/16 in.) canes are **seriously restrictive** to air and milk flow, cause slower milking and limit herd milk produc-

tion as compared to the larger 16 mm (5/8 in.) canes which have **23.5% greater cross-sectional area**. Improvements in air and milk carrying capacity will be somewhat **greater** than the increase in cross-sectional area.

Be certain that both ends of the milk cane are 16 mm (5/8 in.) sized (inside diameter). Some older-style canes are 16 mm (5/8 in.) on the end connected to the milk hose, but, taper down to 14 mm (9/16 in.) or less on the end connected to the milk inlet.

All current milking systems should have 16 mm (5/8 in.) sized (inside diameter) milk canes and inlets. This change alone can significantly reduce milking time and increase herd milk production.

One local 40 cow herd recently upgraded to larger 16 mm (5/8 in.) canes and inlets and reduced total milking time by 15 minutes.

It becomes extremely important to upgrade to larger 16 mm (5/8 in.) canes and inlets at the same time as an upgrade is made to a larger capacity claw with a 16 mm (5/8 in.) outlet. Otherwise, the higher milk flow rate from the claw through an undersized 14 mm (9/16 in.) cane will lead to increased milk agitation, greater teat end vacuum fluctuations, slower milking time and a higher rate of new subclinical mastitis infections.

Milk Hoses

Ensure that milk hoses are kept as short as possible and they don't exceed 2.74 m (9 ft.) in length. Milk hoses may be made of plastic, rubber or silicone. A **16 mm (5/8 in.) sized** (inside diameter) milk hose is recommended.

A **good milk hose hanger** facilitates proper positioning of the unit squarely under the udder with a slight forward pull. Double looped hose hangers make adjustments easier. Ensure that the hanger does not crimp the milk hose and/or long pulsation hoses or a serious restriction to air and milk flow will result causing irregular teat end vacuum fluctuations and improper liner pulsation.

During milking, keep loops in the milk hose to a minimum because milk that collects in the bottom of these loops will surge back and forth and lead to irregular teat end vacuum fluctuations. To prevent loops, minimize hose length and make proper hose adjustments using a good hose hanger. Hoses should be changed at least once every six months or sooner, if they appear opaque and start to feel hard.

Milk Claw

The milk claw is the **collection point** for milk from the four teat cups into the milk hose. The milk claw should:

1. be of adequate capacity to handle peak milk flow without flooding;
2. have a means of shutting-off the vacuum to the teat end (recommended for tie-stall and parlor operations without automatic take-offs);
3. have an outlet the same size diameter as the milk hose (recommend 16 mm (5/8 in.) throughout);
4. have an air vent in the upper half of the claw when in

the milking position to allow a predetermined rate of air into the unit to facilitate milk movement away from the cow and into the pipeline (when vented inflations are used, the claw air vents must be closed).

Routinely inspect each claw for cleanliness, plugged air vents, dented shells and cracked or dented ferrules on the claw. In general, claw cleanliness is a good indicator of overall system cleanliness. A burred or dented ferrule can seriously restrict air and milk flow. This will lead to flooding in the short milk hose and cause wide teat end vacuum fluctuations and uneven milk-out. In most newer claws, ferrule diameter and length have been increased.

Teat-cup Shells

Many types of teat-cup shell and liner combinations are available. Make sure the shell and liner are **compatible**.

Periodically check shells for roundness and dents. If a shell is not oval or is dented, either repair or replace. Make sure that liners are properly aligned in the shells by checking designated marks on each end of the liner body. Check for tightness of fit between liner and shell to ensure there are no leaks. A leak can seriously affect the collapsing and opening action of a liner.

Pulsation

A properly functioning pulsation system is critical to teat and udder health and to ensuring fast, complete milk-out. The pulsator **is the heart** of the milking unit.

As the pulsator operates, it causes the chamber between the shell and the liner to alternate regularly from vacuum to air source. Keep in mind the inside of the teat-cup liner is under milking vacuum at all times. When air is admitted between the shell and liner (Figure 5), the liner collapses around the cow's teat. The pressure of the collapsed liner is applied to the teat giving a massaging action. This is called the **rest or massage phase**. Milk **does not flow** from the teat during this phase.

During the **milk phase** (Figure 6), the space between the liner and the shell is exposed to system vacuum by way of the pulsator. The fact that there is now equal pressure on both sides of the liner causes it to open. The end of the cow's teat is now exposed to milking vacuum. This together with the influence of internal milk pressure within the cow's udder causes milk to be drawn out through the teat opening.

The milking process then consists of opening (milk phase) and closing (rest phase) the teat-cup liner over and over again.

A **pulsation cycle** refers to the total time in seconds that a pulsator takes to complete one milk phase and one rest (massage) phase.

The **pulsation rate** refers to the number of cycles that the pulsator makes in one minute. Pulsators on the market today have pulsation rates ranging from 45 to 60 cycles per minute. Each pulsator must have the same rate, or at least within 5% of the manufacturer's specified rate.

The **pulsation ratio** is the length of time in each cycle

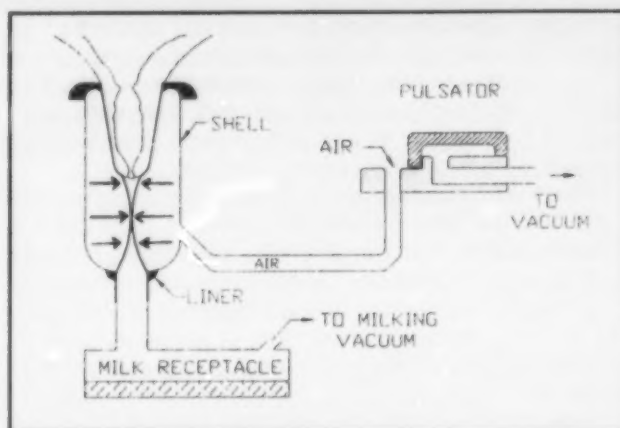


Figure 5. Rest (Massage) Phase

that the pulsator is in its milk phase compared to its rest (massage) phase. The pulsation ratio may be expressed as a single ratio or it can be expressed as a percentage. Common pulsation ratios are as follows: 50:50; 55:45; 60:40; 65:35; and 70:30. A 60:40 ratio means that within any given pulsation cycle, the teat-cup chamber vacuum will be milking 60% of the time and resting (massaging) the teat 40% of the time. Slowest milking time can be expected with a 50:50 milk:rest ratio and fastest with a 70:30 ratio. With a 70:30 ratio, pulsator function must be watched closely to ensure that pulsator wear doesn't lead to a wider ratio and undue stress to the teats (i.e. not enough rest phase).

The **pulsation phase** refers to the method of pulsation known as either simultaneous (4x0) or alternating (2x2) pulsation. Simultaneous (single shot) pulsation is when all four teat cups milk at the same time, then, all four rest (massage) the teats at the same time. Alternating pulsation is when two teat cups milk while two teat cups rest, then, they alternate to complete the pulsation cycle.

Depending on the manufacturer, alternating action may be from side to side or from front to rear. Some front to rear pulsators are preset for a **wider** milk:rest ratio on the rear (i.e. 60:40) than the front (i.e. 55:45). The belief is that this encourages a more uniform and timely milkout of all four quarters.

Alternating pulsation allows a more uniform milk flow into and from the claw thus helping to minimize teat end vacuum fluctuations. Milk:rest ratios of 50:50 in combination with alternating pulsation have been shown to have a high rate of teat end impacts. This in turn can lead to a higher rate of new subclinical mastitis infections. Therefore, it is recommended to **avoid 50:50 milk:rest ratios** in milking units which utilize alternating pulsation.

Pulsators may be either **electromagnetic** or **pneumatic**. Electromagnetic is where all pulsators function together off an electrical signal. Pneumatic is where each pulsator runs off the vacuum system.

Electromagnetic pulsators have an electronic control circuit that turns current on and off to the electromagnet causing each pulsator to perform at a preset pulsation rate

and ratio. Electromagnetic pulsators are unaffected by temperature and they have the advantage of producing a constant pulsation rate. Some electromagnetic pulsators have a computer chip internally mounted. These pulsators function to a preset rate and ratio once they are inserted into a stall cock electrical-vacuum source.

Pneumatic pulsators use air to move a plunger or slide valve to cover and uncover air passages to produce a pulsating action. The plunger or slide valve may be housed in oil for smoother action. The pulsation rate is controlled by a needle valve which may be factory set or may be manually adjustable. Temperature changes as well as system vacuum will affect the pulsation rate of pneumatic pulsators.

Pneumatic pulsators require more maintenance than electromagnetic pulsators. Pneumatic pulsators need to be checked for proper setting and function every one to two months. Since this schedule is usually not adhered to, there tends to be greater variation in pulsation rates and ratios with pneumatic as compared to electromagnetic pulsators. **Electromagnetic, alternating pulsation**, particularly for fast let-down, high producing cows, is recommended.

Filtered Air Pulsation

Despite the movement away from feeding cows in the parlor, dust and aerosols are still present in milking parlor atmospheres. They have a tendency to plug pulsator ports and coat internal valves of pulsators thus causing air flow restrictions, stickiness, excessive pulsator wear and eventual pulsator malfunction. Preventing these problems requires frequent cleaning of pulsators and regular performance checks.

One way to extend cleaning frequency and pulsator life is to install a **filtered air pulsation system**. It is relatively inexpensive and quite effective. A filtered air system is comprised of a separate air line, apart from the pulsation line, that originates from a relatively clean and dry location outside the parlor and extends into and around the parlor. At each pulsator location, a short plastic line links the filtered air line to the pulsator and supplies filtered air. A filter is installed on the end of the air line at its point of origin.

Liners (Inflations)

The best liner is one that milks cows out safely with a minimal number of squawks and without teat-cup crawl. Liner performance is dependent upon adequate sizing of the vacuum pump, regulator performance, proper line sizing, pulsator function and condition of rubberware (i.e. short and long air hoses; age of inflations).

Choose a liner that has a mouthpiece which prevents downward slippage or riding-up action on the teats to the base of the udder. Narrow bore liners are recommended. If a herd is presently being milked with a medium to wide bore-style liner and a switch is made to a narrow one, be conscious of the following facts:

1. Many drop-offs may be experienced at first until the operator relearns how to handle the milker units, such

as putting less tension on the units;

2. Slower milking may be experienced on some cows at first;
3. Some long, flabby teated cows may never be able to adapt to the narrow bore style.

Liners should be replaced on a regular basis, as recommended by the manufacturer.

The method of storage can greatly affect liner life. A dark, cool storage area is recommended. Optimum liner life also depends upon using the proper concentrations of cleaners and sanitizers. A liner must be replaced immediately if it becomes damaged and always replace all four, if one liner needs to be changed.

Based upon the recommendations of a number of manufacturers, the following liner change intervals can be used as a general guideline. However, read label instructions on the box when purchasing new liners to determine the exact recommended change interval:

1. Natural rubber – 500 to 700 cow milkings;
2. Synthetic rubber – 1,000 to 1,200 cow milkings;
3. Silicone type – 5,000 to 10,000 cow milkings.

Several companies are now manufacturing silicone type liners.

The following formula can be used to calculate the desired inflation replacement interval in days:

Days

$$\text{Between} = \frac{(\# \text{ Cow Milkings/Set of Liners}) \times (\# \text{ Units})}{(\# \text{ Cows Milking}) \times (\# \text{ Milkings/Day})}$$

Example: 50 cows milking, 5 units, 1200 milkings per set of inflations, 2 milkings per day.

$$\# \text{ Days Between Changes} = \frac{1200 \times 5}{50 \times 2} = 60 \text{ days}$$

Vented liners which replace the claw air vent are also available. The intent of vented liners is to move milk away from each short milk tube faster and to help eliminate problems with milk backsplashing. Liner vents or claw vents must be checked regularly to ensure that they don't get plugged with debris.

Rubber Parts

It is recommended that all rubber parts and gaskets be replaced annually or sooner if cracks, tears or softness occurs.

Milk hoses may be made of plastic, rubber or silicone. With the exception of silicone hoses, replace milk hoses at least once every six months or sooner if they appear opaque and start to feel hard.

The long pulsation air hoses should be routinely checked for cracks and signs of wear such as softness. Either can seriously affect air flow and liner pulsation. For alternating pulsation hoses with two different ratios, it is very important to ensure hoses are attached to the proper pulsation air ports leading into the claw.

Routinely check the short air tubes on the claw. It is common to find these tubes cracked or torn, particularly

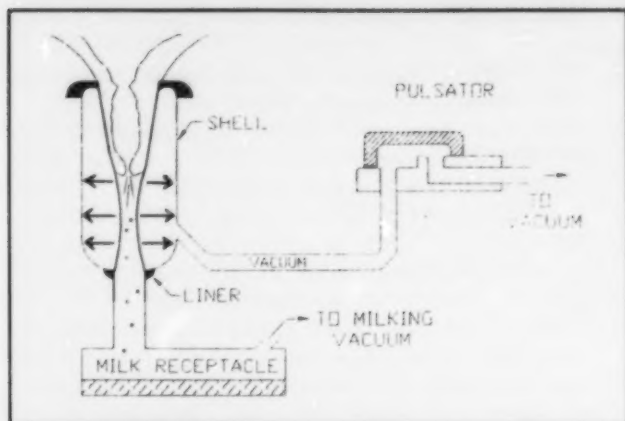


Figure 6. Milk Phase

near the attachment to the ferrule. Replace all short air tubes **at least two to three times a year**. Air flow and liner pulsation will be seriously hampered if short air tubes are cracked, soft or leaking. The same caution should also apply to leaking shells.

When multiple piece liners are in use, replace the short milk tubes at the same time the liners are changed.

Pulsation stall cocks and milk valves are common sites for air leakage. Leaking stall cocks can be corrected by a thorough cleaning and by replacing interior seals. If two or more milk valve seals are leaking, it is recommended that all of them be replaced. Milk valve seals should be replaced at least once every two years.

Pipeline gaskets should be replaced every two years because of daily contact with milk and cleaning solutions.

The appearance of bubbles in the receiver jar indicates the milk pump has a faulty check valve or the gasket at the junction of pump to jar is worn and leaking air. Always have an extra check valve available in case of failure.

It is recommended that all rubber parts be stored in a dark, refrigerated area with low ozone levels away from the vacuum pump.

Wash Diverter Valve (Plug)

When in the milking position, make sure the diverter valve does not restrict milk pipeline diameter. Some diverter valves restrict the pipe's air and milk carrying capacity by as much as two-thirds. If such is the case, use the diverter valve for the sanitation program only and a separate (non-restrictive) milk valve for milking.

Milk Pump and Discharge Pipe

The milk pump is an electric pump which receives milk under vacuum from the receiver jar and discharges it under pressure to the bulk tank. The milk pump interior must be smooth and easily accessible for cleaning. Wiring and connections for the motor must be waterproof. The pump must be activated by either a weight or a level-sensing device. If the latter is of the probe type, probes must be readily demountable for inspection.

The milk pump and discharge pipe must be self-draining. It is recommended that the discharge pipe be **stainless steel** from the milk pump to inside the bulk tank. From the discharge pipe, milk should be discharged to the inside wall of the tank or else to a drop pipe to reduce foaming. The drop pipe should be vented above the maximum possible milk level to prevent siphoning.

Milk Filters

No milk filter should be placed in a milk line or hose which is carrying milk and supplying milking vacuum, simultaneously. Milk filters should be installed only on the discharge side of the milk pump; usually in the pipe between the milk pump and the bulk tank.

Weigh Jars

Weigh jars should be mounted as low as possible so that milk does not have to be lifted from the udder to the top of the jar. Jars tend to be expensive and they are a challenge to clean. Those with milk inlets that have an inside diameter of 12 mm (1/2 in.) or 14 mm (9/16 in.) are **restrictive** to air and milk flow. Therefore, based on these reasons, it is recommended that milking parlors be designed without weigh jars.

If jars are to be installed, use only those with a 16 mm (5/8 in.) size (inside diameter) milk inlet. The minimum acceptable height for milk recording purposes as stated by the Canadian Milk Recording Board (CMRB) is that the 2 kg graduation mark be at least 90 cm (35.1 in.) from the floor. Two advantages to installing weigh jars with a properly-sized milk inlet are: they provide vacuum stability to the cow similar to a bucket system and they provide a quick visual means for monitoring individual cow production at each milking.

Milk Meters

Several types of milk meters are **restrictive to air and milk flow** as a result of their design. These restrictions cause a drop in teat end vacuum and the occurrence of irregular teat end vacuum fluctuations. These effects in turn can lead to increased milking time, incomplete milk-outs and, in some cases, contribute to new subclinical and clinical mastitis infections. Observations vary among herds, depending upon herd average production level and management.

Field experience indicates that many herd owners could improve milk meter performance by ensuring that vacuum pump capacity is adequate, that the regulator is routinely serviced and working at peak efficiency, that there are no restrictions in the vacuum supply lines, the milk line, the receiver jar or the trap, that milk line slope is continuous and adequate, that current recommended sizes (ie. 16 mm (5/8 in.)) for milk inlets and canes are being used, and that milk inlet positioning is in the top third of the milk line, preferably in the 11 or 12 o'clock position.

Herd owners are also strongly advised to adhere to the manufacturer's installation and operational specifications

to ensure best milk meter performance (i.e. keeping each meter in a vertical position; system vacuum adjustments; meter cleanliness; keeping hoses short and loop-free to and from the meter).

End of Milk Sensors (Indicators)

Milk sensors are automatic devices for detecting and signalling to the operator the **end of milking**. They operate by electrical conductivity of by-pass bleed valves. Their advantage is that they add consistency to the time units are removed and tend to assist the operator in reducing total milking time. They are an asset in operations where several people are milking the cows or where there is a constant change in hired help.

Many new generation milk sensors are outside of milk flow and are not restrictive. Compared to older milk sensors, the newer models tend to be smaller, require less maintenance, are easier to handle and are more accurate.

Automatic Take-Offs

Automatic take-offs are becoming increasingly popular in milking parlors and more recently, in tie-stall barns as labor-saving devices. The automatic take-off removes the milker unit from the cow once the milk flow has been sensed to be below a certain flow rate. Take-offs can range from simple vacuum operated units controlled by milk flow float sensors to sophisticated electronic devices. Restrictions to air and milk flow are minimized by good design. Be cautious of devices with restrictions since they can increase milking time and limit herd milk production.

In general, automatic take-offs should do the following:

1. they should sense end of milk flow without over-milking;
2. they must be designed to shut-off vacuum to the claw before starting to retract the unit;
3. they should have as little restriction as possible to milk flow from claw to pipeline;
4. they should be easily cleaned-in-place;
5. they should be regularly checked for efficiency of removal.

Some milking management points to consider when using automatic take-offs are the following:

1. a milk hose support is necessary to help achieve even milk-out between front and rear quarters;
2. automatic take-offs should be installed at a height that is not conducive to lifting milk from the claw, instead, they should allow milk to flow directly down to the milk line from the claw;
3. three-quartered cows, cows with problem quarters and slow milking cows, may not be milked out properly using automatic take-offs;
4. cows must be prepared properly for good milk let-down.

Sanitation Program

All milk contact surfaces must be sanitized before and cleaned after each milking. System cleaning is a function of **time, temperature, turbulence, and solution contact and strength**. Failure in any one of these areas can seriously impair the effectiveness of a sanitation program.

Most installations utilize automatic washers. In some instances, a separate automatic washer is used for the

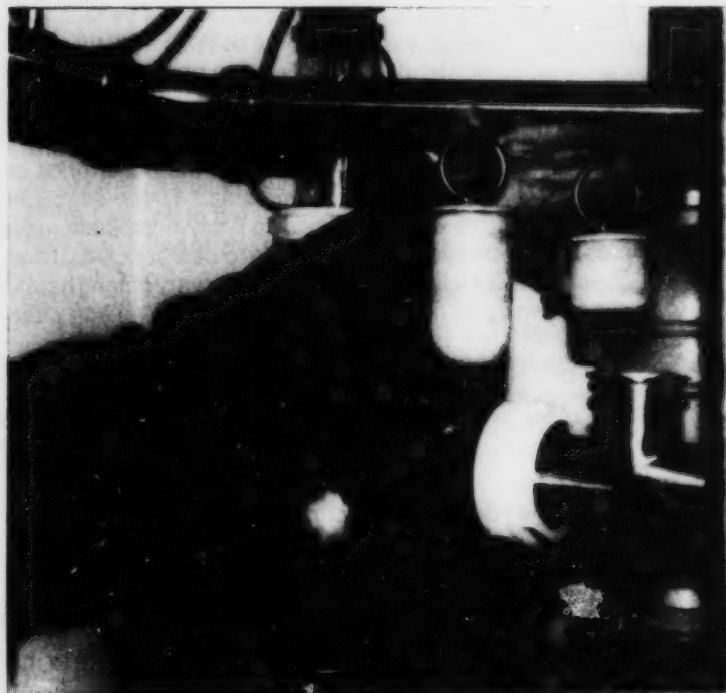


Photo 7. Wash Diverter Valve versus a Milk Valve

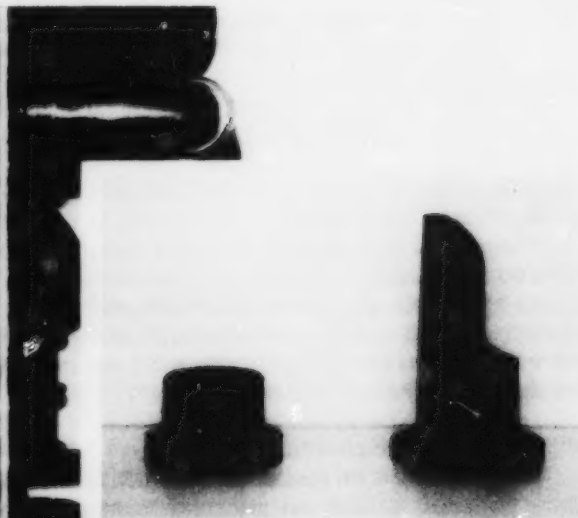


Photo 8. (Inset)
Wash Diverter Valve versus a Milk Valve

bulk tank. The automatic washer uses four basic cycles:

1. after milking rinse (removes milk residue);
2. hot detergent wash (removes butterfat and protein);
3. acid rinse (removes salt and water minerals);
4. before milking sanitize rinse

One of the most critical components of the sanitation program is the hot water tank. It must be thermostatically adjustable to provide hot water up to 77°C (170°F) and be of sufficient capacity to meet all system hot water requirements. It is recommended that only industrial hot water tanks be installed with both upper and lower thermostats. The top thermostat should be adjusted to 71°C (160°F) and the bottom thermostat to 77°C (170°F).

Have an accurate thermometer available to regularly check (once a month) solution temperatures and periodically time each of the cycles.

The **after milking rinse** should start at 43°C (110°F), circulate **only once** through the system then be discharged at a temperature not less than 32°C (90°F).

The **hot chlorinated alkaline detergent wash** cycle should start at 74°C (165°F), circulate through the system a minimum of five minutes to a maximum of 10 minutes before being discharged at a temperature not less than 49°C (120°F). Solution pH should be 11 to 12.

Use an **acid rinse** immediately after **every** wash cycle. The acid in the rinse will neutralize any alkaline and chlorine residues left in the system and on the liners. If not neutralized, chlorine will oxidize liners and rubber parts and shorten their life. Depending on the brand name, the temperature of the acid rinse may range from 10 to 43°C (50 to 110°F). Read product label instructions for proper water temperature setting. Solution pH should be 2 to 3.

Always **sanitize** the system before milking. Read product label instructions carefully since usage rates can vary substantially among brands.

The **main reason** for reduced life of liners and rubber parts is wrong concentrations of detergents, chlorine and acids at wrong usage rates. Read instructions carefully.

A good water softener might be helpful in reducing the amount of cleaners to use on farms with hard water. An iron filter may also be beneficial. Have the farm's water supply tested for hardness then refer to product label instructions.

For cleaned-in-place systems, the installation of an adjustable **air injector** for both rate and duration is recommended. An air injector aids in producing cleaning solution turbulence and solution contact throughout the system to ensure maximum cleaning performance.

Water volume is a critical component of the system cleaning. The following guidelines are for calculating washwater volume requirements:

1. 3.2L (0.7 gal. imp.) per 3.0 m (10 ft.) of 38 mm (1.5 in.) line;
2. 3.2L (0.7 gal. imp.) per 2.4 m (8 ft.) of 51 mm (2.0 in.) line;
3. 3.2L (0.7 gal. imp.) per 1.2 m (4 ft.) of 76 mm (3.0 in.) line.

Always aim for a minimum of 102 to 152 mm (4 to 6 in.) of water in the wash vat at all times. Wash intake pipes in the wash sink must not be allowed to draw in air during the wash cycle or the water will cool prematurely and result in an inadequate wash.

Line slope is also very important to ensure complete drainage of chemical solutions following each cycle. Make sure that all lines are adequately sloped – 25 mm per 3 m (1.0 in./10 ft.) for welded lines and 38 mm per 3 m (1.5 in./10 ft.) for coupled lines.

Greater vacuum pump capacity (or higher air flow rates) is required to wash a system than to milk with it. A system which is borderline on air flow for milking will likely be lacking sufficient air flow for effective washing action.

Backflush Systems

Backflush systems are commonly used in milk parlors. A backflush system automatically flushes water and/or germicidal solution through the long milk hoses, teat-cup liners and claws between each cow after milking. The objective is to reduce the bacterial population on the inner surfaces of the liners and claws, thus reducing the risk of spreading mastitis-causing bacteria among cows and to maintain low bulk milk bacteria counts. A backflush system is usually designed to first remove residual milk with a warm water rinse, followed by a sanitizing solution rinse, a brief pause for germicidal action, a post water rinse, and removal of remaining backflush liquids by a short blast of filtered compressed air.

In-line Milk Pre-coolers

In-line milk pre-coolers shorten milk cooling times by accelerating cooling rates. They function by removing a portion of the heat directly from the milk before it reaches the bulk tank. This in effect reduces the work demand on the bulk tank and its compressor. In-line pre-coolers are usually tubular style or plate-type heat exchangers that utilize cool well water to absorb heat from the milk as it passes through to the bulk tank. Water continuously passes through the pre-cooler during the operation.

To ensure effective cleaning of the pre-cooler and efficient cooling of the milk, the pre-cooler must be sized according to the pumping capacity of the milk pump. Refer to the manufacturer's specifications to ensure that pre-cooler and milk pump capacities are compatible.

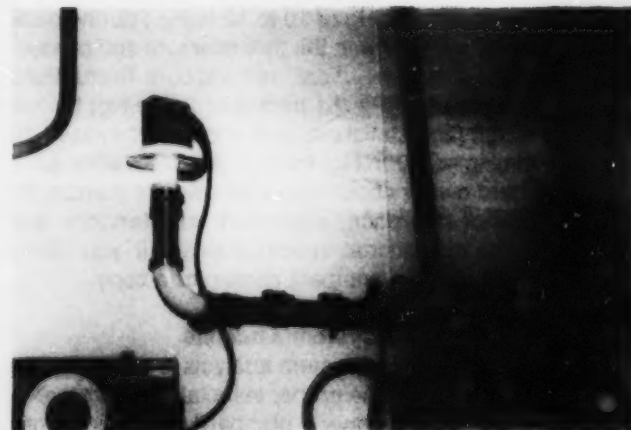


Photo 9. Air Injector

In instances where solution strengths and water temperature are less than adequate, the pre-cooler will be one of the first components of the milking system to not clean properly. If milk bacteria counts begin to rise, take the pre-cooler apart, examine it for cleanliness and, if necessary, manually clean before reassembling it. Correct any deficiencies in the sanitation program to prevent a recurrence of the same problem.

Bulk Milk Tank (Cooler)

The bulk tank is the storage vessel for cold raw milk until it is picked up by the bulk milk hauler. All tanks must meet 3A Standards for sanitary design and construction, and be of **sufficient capacity** to cool and store up to three days milk or six milkings. All tanks must have the capability of cooling the first milking to 10°C (50°F) or lower in one hour or less and to 4°C (39°F) or lower in two hours or less. The blend temperature when subsequent milkings enter the tank must not rise above 10°C (50°F) and the milk must be cooled to 4°C (39°F) or lower in one hour or less.

Immediately after the tank is emptied, the hauler must rinse the interior with cold or lukewarm water. Then the tank should be cleaned according to the same sanitation program as required for the rest of the milking system after each milking. Prior to adding the first milking, sanitize the inner tank surface with an approved dairy sanitizer.

First Time Use of a New Milk Pipeline

Before using a newly installed milk pipeline, make sure that you know all aspects of its operation for both milking and cleaning. The milking equipment dealer/installer should be present during at least the first two complete cow milkings and sanitation cycles.

Measurements, such as vacuum pump capacity, air leakage, milker unit operating losses, system vacuum reserve, pulsation rates and ratios of each pulsator and vacuum regulator performance should be taken and recorded for future reference.

Depending on exact system design, high line vacuum levels are usually set at 47 to 51 kPa (350 to 381 mmHg or 14.0 to 15.0 in.Hg), while low lines are set at 42 to 47 kPa (314 to 350 mmHg or 12.5 to 14.0 in.Hg).

It is desirable to have teat end vacuum set around 33 to 40 kPa (247 to 300 mmHg or 10 to 12 in.Hg.) during peak milk flow. This will vary with the milk flow rate and production level of each cow. Teat end vacuum fluctuations should not exceed 7 kPa (51 mmHg or 2.0 in.Hg) for low line and weigh jar installations and should not exceed 10 kPa (76 mmHg or 3.0 in.Hg) for high line installations.

Every herd owner should have an owner's manual for the purpose of reference, equipment maintenance and adherence to operational specifications. If you don't, contact your milking equipment dealer for a copy.

Regularly Scheduled System Analysis

A regularly scheduled system analysis is just as important as the design and the proper installation of a system. Most licensed dealers have a standard system analysis worksheet on which they record various performance

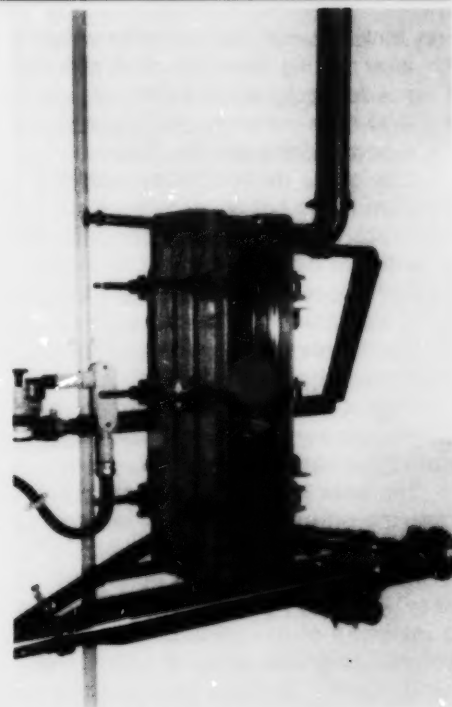


Photo 10. In-line Milk Pre-cooler

measurements and identify areas or components requiring servicing or upgrading.

A complete system analysis should be conducted at least once a year and records kept for future reference. A sample of a milking system analysis worksheet is included at the end of this publication. A milking system which is maintained at peak performance will ensure that herd milk production, milk quality and udder health aren't sacrificed.

Summary

Milking equipment serves an integral role in every dairy enterprise. Herd production and profitability can be greatly influenced by milking system performance. Today's milking systems are highly specialized and require operators to have a good working knowledge of its basic components, their function, and proper procedures for use, maintenance and sanitation.

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MILKING SYSTEM ANALYSIS WORKSHEET

PRODUCER INFORMATION

Producer _____

Date _____

Address _____

Phone _____

Equipment Brand(s) _____

Total # Cows _____

Equipment Dealer _____

Type of Facility _____

SCHEMATIC DIAGRAM OF MILKING SYSTEM

MILKING SYSTEM DESCRIPTION

Tie-Stall _____ Free-Stall _____ Parlor _____ High Line _____ Low Line _____
 Vacuum Pump: Make/Model _____ Rating _____ cfm ASME
 Intake Pipe Size _____ in. Exhaust Pipe Size _____ in. Exhaust Flapper Valve _____ Y/N
 Oil Reclaimer _____ Y/N Last Serviced (Pump & Oil Reclaimer) _____
 Vacuum Pump Motor: RPM _____ HP _____ Oil Level _____ Belt Condition _____
 Main Vacuum Supply Line: (vacuum pump to vacuum tank)
 Type _____ Size _____ in. # Elbows _____ Restrictions _____
 Vacuum Tank: Type _____ Size _____ gal. Location _____
 Drain Valve Type & Condition _____ # Ports _____ Port Size _____ in.
 Tank Condition _____
 Vacuum Regulator: Location _____ Rating _____ cfm
 Type _____ Condition _____
 Vacuum Relief Valve: Present _____ Y/N Location _____
 Setting _____ in. Hg
 Vacuum Gauges: # _____ Location _____ Setting _____ in. Hg
 Vacuum Header Lines:
 A. Milk: Type _____ Size _____ in. # Elbows _____
 B. Pulsation: # Lines _____ Type _____ Size _____ in. # Elbows _____
 Moisture Trap: Type _____ Port Size _____ in. Condition _____
 Milk Receiver Jar: Vacuum Supply Inlet Size _____ in. (rec'd 3.0 in.)
 # Milk Inlets _____ Milk Inlet Size _____ in. (min. 2.0 in.)
 Pulsator Line: Type _____ Size _____ in. Looped _____ Y/N
 Drain Valves: _____ Y/N Proper Slope _____ Y/N (min. 0.5 in./10 ft.)
 Milk Line: Type _____ Size _____ in. Length _____ ft.
 # Units/Slope _____ Max. Height from Cow Platform _____ ft. Proper Slope _____ Y/N (min. 1.0 in./10ft.)
 Location _____
 Milk Line Inlets: Type _____ Inlet Size _____ in. (rec'd 5/8 in.) Condition _____
 Location _____ (rec'd 11 to 12 o'clock position)
 Milk Hose Canes: Type _____ Size _____ in. (rec'd 5/8 in. inside dia. both ends)
 Milk Hose: Type _____ Size _____ in. (rec'd 5/8 in. inside dia.)
 Milk Claw: No. Units _____ Outlet Size _____ in. (rec'd 5/8 in. inside dia.) Type _____
 Shut-off Valve: _____ Y/N
 Pulsators: Type _____ Electronic/Pneumatic Last serviced _____ Condition _____
 Inflations: Type _____ Brand _____
 Rec'd Change Interval =
$$\frac{(\# \text{ Cow Milkings/Set of Liners}) \times (\# \text{ Units})}{(\# \text{ Cows Milking}) \times (\# \text{ Milkings/Day})}$$

 Condition of:
 Air Vents _____ Inflations _____
 Short Air Tubes _____ Long Air Tubes _____
 Short Milk Hoses _____ Long Milk Hoses _____
 Automation (meters; sensors; ACR's) _____

MILKING SYSTEM PERFORMANCE ANALYSIS

I. SYSTEM VACUUM LEVEL _____ in. Hg

Recovery Time Test: Override Y/N Recovery Time _____ sec. (rec'd ≤ 3 sec.)

II. REGULATOR FUNCTION (Air Flow Tests Run @ System Vacuum Level of _____ in.Hg)

A. Regulator Capacity Test

(regulator in; drop vacuum 0.5 in.Hg) _____ cfm ASME (min. 90% of B.)

B. System Operating Capacity Test

(regulator out; system vacuum) _____ cfm ASME

III. SYSTEM VACUUM SUPPLY (Air Flow Tests Run @ 15.0 in.Hg)

C. Vacuum Pump Output Test _____ cfm ASME (min. 10 cfm ASME/unit)

D. Total System Capacity Test

(regulator out; units & pulsators off) _____ cfm ASME (min. 80% of C)

E. Reserve System Capacity Test

(regulator out; units & pulsators on) _____ cfm ASME (min. 30 cfm ASME reserve)

IV. PULSATION (Static Tests With Pulsation Recorder)

Pulsation Phase Alternating/Single Shot Front to Back/Side to Side

Pulsation Rate (rec'd _____ pulses/min.)

Pulsation Rate (measured):

Pulsator 1 _____ Pulsator 5 _____

Pulsator 2 _____ Pulsator 6 _____

Pulsator 3 _____ Pulsator 7 _____

Pulsator 4 _____ Pulsator 8 _____

Pulsation Ratio (rec'd Milk _____% : Rest _____%)

Pulsation Ratio (measured)

Pulsator 1 _____ Pulsator 5 _____

Pulsator 2 _____ Pulsator 6 _____

Pulsator 3 _____ Pulsator 7 _____

Pulsator 4 _____ Pulsator 8 _____

V. MILKING VACUUM

Milk Line Vacuum Fluctuation (all units on) _____ in.Hg. (max. 0.25 in.Hg)

Milk Claw Vacuum Level Under Peak Flow _____ in.Hg. (rec'd 10-12 in.Hg)

Milk Claw Vacuum Fluctuation Under Peak Flow _____ in.Hg.

(Low Line - max. 2.0 in.Hg.)

(High Line - max. 3.0 in.Hg.)

Milk Flow Into Receiver Jar (describe) _____ (no slugs)

SANITATION PROGRAM ANALYSIS

I. WATER VOLUME

Water Used Estimate _____ gal. (Imperial)

Minimum Level In Wash Vat _____ in.

(rec'd min. 4-6 in. at all times)

*Rec'd 3.2 L (0.7 gal.) per 3.0 m (10 ft.) of 38 mm (1.5 in.) line; or

3.2 L (0.7 gal.) per 2.4 m (8 ft.) of 51 mm (2.0 in.) line; or

3.2 L (0.7 gal.) per 1.2 m (4 ft.) of 76 mm (3.0 in.) line.

*(Assuming that a properly sized air injector is installed.)

II. HOT WATER TANK

Capacity _____ gal. Age _____ yrs. Condition _____

Water Temp. Direct From Hot Water Tap _____ °C (_____ °F)

Thermostat Settings:

Top _____ °C (_____ °F) (rec'd 71°C (160°F.))

Bottom _____ °C (_____ °F) (rec'd 77°C (170°F.))

III. AFTER MILKING RINSE

Starting Temp. _____ °C (_____ °F) (rec'd max. 43°C (110°F.))

Dump Temp. _____ °C (_____ °F) (rec'd min. 32°C (90°F.))

Circulation _____ # or min. (rec'd once around & dump)

IV. HOT DETERGENT WASH

Starting Temp. _____ °C (_____ °F) (rec'd min. 74°C (165°F.))

Dump Temp. _____ °C (_____ °F) (rec'd min. 49°C (120°F.))

Circulation Time _____ min. (min. 5 min. to max. 10 min.)

pH (start of cycle) _____ (min. pH = 11)

pH (mid-cycle) _____ (rec'd same pH as start of cycle)

V. ACID RINSE

Starting Temp. _____ °C (_____ °F) (rec'd 10 to 43°C (50 to 110°F) varies among brands)

Dump Temp. _____ °C (_____ °F)

Circulation Time _____ min.

pH (start of cycle) _____ (max. pH = 3)

pH (after one circulation) _____ (rec'd same pH as start of cycle)

Frequency of acid rinsing _____ (rec'd after every milking after every wash cycle)

VI. BEFORE MILKING SANITIZE RINSE

Sanitize Rinse Y/N Product _____

VII. AIR INJECTOR

Present Y/N Type _____ Location _____

Setting: Open _____ sec. Closed _____ sec. (rec'd 2-3 sec. open to 9-12 sec. closed)

Describe slugging action in lines/jar _____

VIII. OTHER COMMENTS ABOUT SANITATION PROGRAM

Appendix I: Calculating Vacuum Head Loss*

Table 1. Vacuum Head Loss in Inches of Mercury (in.Hg) Per 100 Feet of PVC Pipe

CFM ASME	Pipe Diameter (in.)		
	2	3	4
40	.412	-	-
50	.589	.086	-
60	.817	.119	-
70	1.078	.156	-
80	1.147	.199	.051
90	1.434	.245	.075
100	1.709	.296	.075
150	-	.614	.156
200	-	1.033	.261
250	-	-	.391
300	-	-	.543
350	-	-	.717
400	-	-	.914

Table 2. Straight Pipe Equivalent of Various Fittings In Feet

Nominal Pipe Size (in.)	Inside Diameter (in.)	45° Standard Elbow	90° Standard Elbow	90° Long Radius Elbow	Standard Through Run	Tee Side Run
1.5	1.610	2.14	4.02	2.68	2.68	8.1
2	2.067	2.75	5.2	3.44	3.44	10.3
2.5	2.469	3.30	6.2	4.12	4.12	12.4
3	3.068	4.10	7.7	5.1	5.1	15.4
4	4.026	5.4	10.1	6.7	6.7	20.1
6	6.065	8.1	15.1	10.1	10.1	30.3

NOTE: 1 in. = 2.54 cm = 25.4 mm
1 ft. = 0.3048 m

Table 3. Vacuum Head Loss in Inches of Mercury (in.Hg) Per 100 Feet of Straight, Standard Pipe**

CFM ASME	Pipe Diameter (in.)		
	2	3	4
40	.5879	-	-
50	.8415	.1225	-
60	1.1671	.1696	-
70	1.5397	.2234	-
80	-	.2837	.0723
90	-	.3504	.0899
100	-	.4232	.1077
150	-	.8775	.2226
200	-	1.4746	.3733
250	-	-	.5581
300	-	-	.7756
350	-	-	1.0249
400	-	-	1.3053

**At 12 in.Hg. Nominal Vacuum

SOURCE: Steve Spencer "The Basics of Vacuum in Milking Systems"

Sample Calculation of Vacuum Head Loss:

Determine the head loss in a 3.0 in. PVC pipe from the regulator to the pump. The pump size is 90 CFM ASME. There are six 90° standard elbows and 52 feet of straight pipe.

From Table 2 (Appendix I)

6 elbows at 7.7 ft. each = 46.2 ft. (straight pipe equivalent)
plus 52 ft. of straight pipe = 52.0
TOTAL = 98.2 ft. (straight pipe equivalent)

From Table 1 (Appendix I)

3.0 in. PVC pipe at 90 CFM = 0.245 in.Hg head loss per 100 ft. of pipe
Therefore, head loss = $\frac{98.2}{100} \times 0.245 = 0.24$ in.Hg head loss

Conclusion: The 3.0 in. main vacuum supply line is of adequate size because the vacuum head loss (0.24 in.Hg) is less than 0.5 in.Hg. NOTE: Vacuum head loss in the main vacuum supply line should not exceed 1.7KPa (12.7 mmHg or 0.5 in.Hg).

*SOURCE: Appendix II of the 1990 Guidelines for the Installation and Operation of Milking and Milk Handling Equipment, published by the National Liaison Group on Milk Quality.

Appendix II: Vacuum Pump Capacities of Available Models from each Milking Equipment Manufacturer*

Model	Motor Size H.P.	Pump Speed R.P.M.	CFM ASME 51 KPa (15")	L/min. ASME	Model	Motor Size H.P.	Pump Speed R.P.M.	CFM ASME 51 KPa (15")	L/min. ASME
BOU-MATIC					ALFA-LAVAL				
FR3A	3	1500	30.0	849	76	2	920	27.0	764
FR3A (direct drive)	5	1725	42.5	1203	76	3	1250	36.0	1019
FR4A	3	1150	37.5	1061	78	5	800	60.0	1698
FR4A	5	1500	47.5	1344	78	7.5	1090	80.0	2264
FR4A (direct drive)	7.5	1725	62.5	1769	78	10	1270	100.0	2830
DB2000	7.5	-	77.5	2193	84	10	760	120.0	3394
DB2000	10	1130	100.0	2830	84	15	950	150.0	4245
UNIVERSAL					86	15	760	160.0	4528
306052	3	1185	35.0	991	86	20	950	200.0	5660
307002	3	875	32.0	907	RPA16 (direct drive)	10	1750	78.0	2207
307003	5	1050	50.0	1416	RPA19 (direct drive)	15	1750	120.0	3396
306054	5	1050	57.0	1615	RPA21 (direct drive)	20	1750	170.0	4811
306057	7.5	1000	83.0	2351	SURGE				
306061	10	1285	100.0	2833	40 Plus	2.4	1025	20.0	566
WESTFALIA					60 Plus	3.5	795	30.0	849
RPS1200	3	1225	32.0	906	75 Plus	4.5	860	34.5	976
RPS2800	5	740	50.0	1415	100 Plus	5.5	1150	50.5+	1415
RPS2800	7.5	1030	76.2	2156	200 Plus	9.5	1150	100.0	2830
RPS2800	10	1230	103.2	2921	550	2.4	1025	20.0	550
ZERO					1200	4.5	1150	43.0	1200
300 T-3	3	450	30.0	849	1400	5.5	1150	51.0	1400
325 T-3	3	470	32.0	906	2300	8.0	1150	82.0	2300
500 T-3	5	715	50.0	1415	2800	9.5	1150	100.0	2800
525 T-3	5	670	52.0	1472	4600	15.0	1170	164.0	4600
750 T-3	7.5	895	75.0	2140	5600	20.0	1170	200.0	5600
775 T-6	7.5	895	75.0	2140	CHORE-BOY				
1000 T-6	10	1245	105.0	2972	ML-30	3	1175	34.0	962
1500 T-6	15	1250	130.0	3679	ML-50	5	1000	55.0	1557
					ML-75	7.5	900	63.0	1783
					ML-100	10	1175	86.0	2434

*SOURCE: Appendix III of the 1990 Guidelines for the Installation and Operation of Milking and Milk Handling Equipment, published by the National Liaison Group on Milk Quality.

Appendix III: National Distributors of Milking Equipment

SURGE (CANADIAN)

Babson Brothers
300 Ambassador Drive
MISSISSAUGA, Ontario
L5T 2J3
(416) 270-5985
1-800-668-5534

MUELLER (U.S.A.)

Paul Mueller Company
P.O. Box 828
SPRINGFIELD, Missouri
65801
(417) 831-3000

UNIVERSAL

Universal Dairy Equipment Inc.
11100 North Congress Avenue
KANSAS CITY, Missouri
64153
(816) 891-2430

CHORE BOY

Chore Boy
Mr. Ron Napier
P.O. Box 151
CAMBRIDGE CITY, Indiana
47327
(317) 478-3201

DAIRY EQUIPMENT CO. (BOU-MATIC)

Dairy Equipment Co.
P.O. Box 8050
MADISON, Wisconsin
53708
(608) 222-3484

WESTFALIA

3169 Joseph Dubreuil St.
LACHINE, Quebec
H8T 3H6
1-800-361-6040

NU PULSE AMERICA INC.

908 Stewart Street
MADISON, Wisconsin
53713
(608) 274-2722

ZERO (Parts Only)

Zero Manufacturing Co.
811 Duncan Avenue
WASHINGTON, Missouri
63090
(314) 239-6721

ALFA-LAVAL (CANADA)

Alfa-Laval
2020 Fisher Drive
PETERBOROUGH, Ontario
K9J 7B7
(705) 741-3100

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PUBLICATIONS

**The 1990 Guidelines for the Installation and Operation of
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by The National Liaison Group on Milk Quality

The Professionals Approach to Quality Milk Production
a 1989 course manual
by Dr. David Reid and Dr. Andrew Johnson, Wisconsin, U.S.A.

Understanding the Basics of Milking Machines
a 1989 Ontario Government factsheet by George A. Garland

Installation Recommendations for a Milk Pipeline
a 1989 Ontario Government factsheet by George A. Garland

INDIVIDUALS & ORGANIZATIONS

Manitoba Mastitis Control Committee
Canadian Milk Recording Board (CMRB)
Canadian Milking Management Association
Manitoba Milking Equipment Dealers Association
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